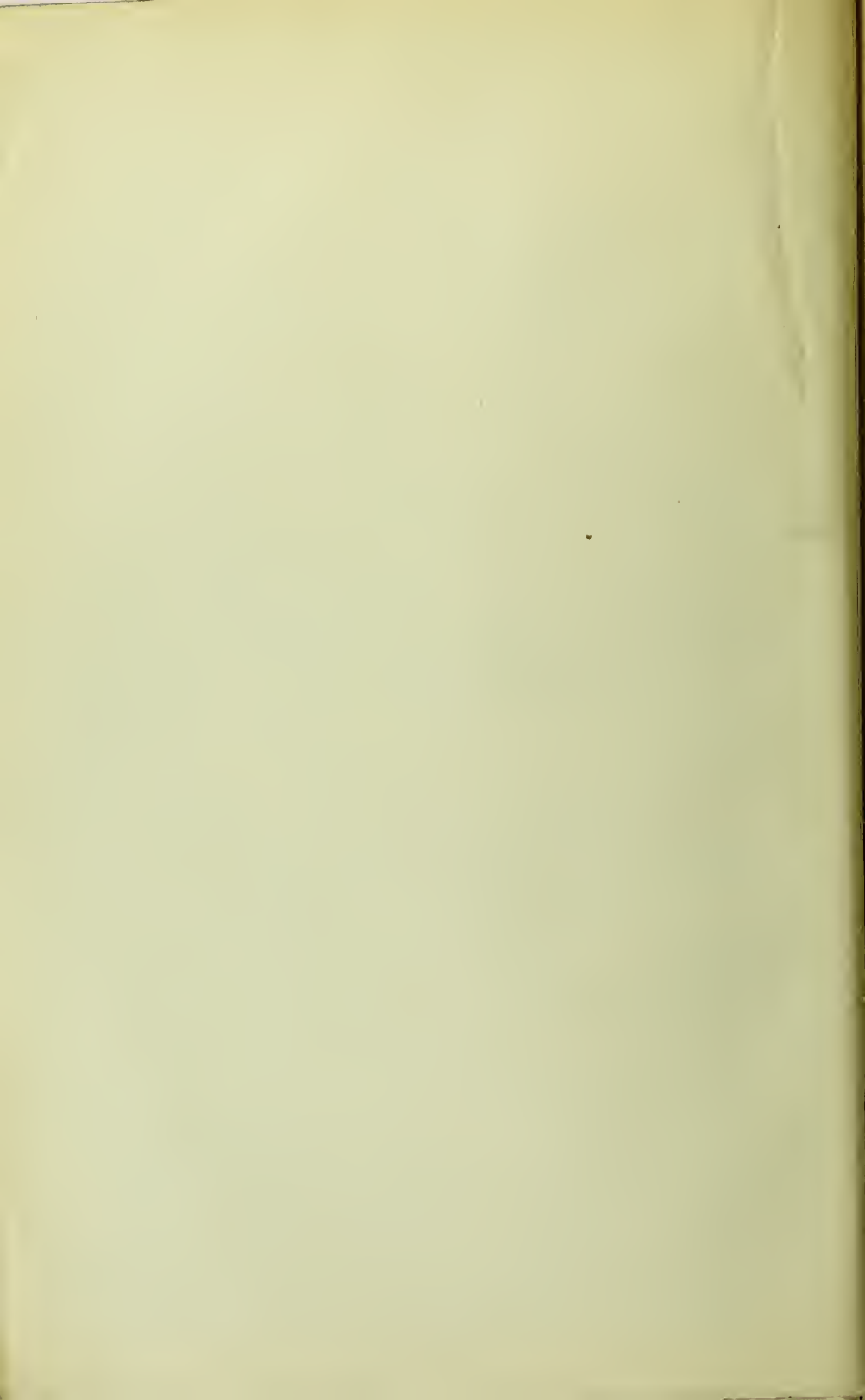


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From the Northumberland Sea Fisheries Report for 1906.



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THE MUSSEL BEDS OF NORTHUMBERLAND.

(WITH MAPS I.—VI.)

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The following is an account of an investigation of the Mussel Beds of Northumberland, undertaken during the sessions 1905-6 and 1906-7, with the intention of making a study of the condition of the mussels in the various beds, their breeding seasons, and the nature of their surroundings. There is a great want of mussels for bait along the coast, the chief reasons for the scarcity being improvidence in over-gathering, and the action of storms which carry away the spat and prevent its settling, often also destroying the shelter of the existing beds. The mud and sand brought down by floods and currents during such storms are harmful, as they frequently choke up and kill large patches of mussels. In no case does there seem to be any pollution of the beds, the scaups being situated in favourable places, which are comparatively free from the risk of sewage contamination.

The mussels which are or have been cultivated are all worked on the bed system, which seems the only suitable method on this coast. The Buchot system used so much abroad could only be applied at Budle and Holy Island; it would, however, be inadvisable to risk so much expense on a venture which most probably would be unsuccessful, as it has been tried on the Scotch mussel beds with small success.

The only bed on this coast which can really be said to be cultivated now is that at the mouth of the River Waren (*i.e.*, Budle Bay), where good mussels are flourishing, although not now in great numbers.

It is well known that it is chiefly in the neighbourhood of river mouths that mussels are to be found, and there are several such suitable places between the Tyne and the Tweed, the following rivers opening into the sea:—Blyth, Wansbeck, Lyne, Coquet, Aln, and Waren. Of the small streams or burns those running on to Fenham Flats are of significance, and the Holywell Burn at Seaton Sluice may be mentioned. The Tyne must be put out of consideration altogether, the present conditions being quite unsuited to

the growth of mussels, although some years ago good bait was obtained from a bed lying about the Black Midden Rocks on the north side of the river; this bed was, it is said, completely destroyed by starfish. The Blyth and the Coquet both offer favourable places, and Budle Bay yields the best mussels in all Northumberland, whilst the Scaup, Holy Island, and the Fenham Slakes yield the greatest number; also there is a fair amount of mussels in the bed of the Tweed. The Aln had a good-sized mussel bed which flourished a hundred years ago, but the conditions are now unfavourable for any mussel growth. Although a search has been made along the coast for other likely places in which mussels might be planted, none has been found. A small experiment was made at Seaton Sluice, and mussels were planted, but it was unsuccessful. The available space at the mouth of the Wansbeck is really too small for any use to be made of it, although the beach on the north bank at the ferry landing seems suitable ground. The banks of the Lyne are too sandy near its mouth, and further up are too grassy to be useful for mussel planting. If ground for this purpose be wanted, it could, I think, only be found at or near the places where the mussels already are, and there appears to be plenty of additional space available in some of these localities.

I now proceed to give a brief sketch of each mussel bed in order, beginning at Blyth and going north.

BLYTH (SEE MAP I.).—The harbour of Blyth is a very good place for sheltering mussels. It lies just at the mouth of the River Blyth, where the numerous piers with woodwork and the nearly-enclosed harbour afford much protection, and where the pebbles and sandy mud on both sides, but more especially on the left bank of the river, offer excellent conditions for the mussel to live and grow. Blyth Harbour stands on the sandstones and shales of the Coal Measures, and some way up the river was an ancient forest, now submerged. Portions of large trunks of trees still remain on the river bank, and stags' horns have often been brought up by the dredgers. It is on the site of this ancient forest that a thriving mussel bed formerly existed. It is a muddy flat on the left bank of the river, well above the harbour. Mussels also occur just opposite on the right bank, but are more thinly scattered. The ground is flat, and wet mud extends for some distance, with here and there sand and small stones, and the trunks of old trees on which grow *Fucus* and other seaweeds. A very small stream runs over this

part, and along its course the mussels are rather more plentiful and not so much buried in the mud. With the exception of these the mussels are to be found close to the water's edge at low tide, very much scattered, sometimes a few together, sometimes isolated. All burrowing in the mud, generally so deep that only the smallest part of the posterior end of the shells is visible. They are very difficult to find when one is not used to it, but the practised eye of the fisherman soon finds them out, and many people search for them at low tide. These mussels are not altogether native; some were planted by Mr. Dent in 1893, and grew well for a time. Those that are still to be found are good, the average size being $2\frac{1}{2}$ to $2\frac{3}{4}$ inches long, and nearly all of the particular variety known to conchologists as *galloprovincialis*. The shells are very smooth, since, owing to their burrowing habit, few encrusting animals or weeds grow on them. The shape is usually broad and flat, which is frequently seen in burrowing mollusks.

The animals collected were all perfectly healthy; several of the stomachs were examined and were full of fine mud, containing a plentiful supply of food, chiefly Diatoms, one commonly occurring was *Melosina montagui*. The spatting is certainly over by the end of September, as all the specimens then seen were spent. By January they are filling out well, and begin to be ripe about June. The summer months are evidently the breeding season.

The commonest mollusks living with the mussels are *Cardium edule*, *Macoma balthica*, *Scrobicularia plana*, *Mya arenaria*, *Littorina littorea*, *L. rudis*, *L. obtusata*, and *Paludetrina stagnalis*. The 'clams' (*Mya arenaria*) occur abundantly at extreme low water mark in the bed, burrowing about six inches in the mud. The shells are small and as a rule distorted, but the people dig them up and eat them. In spite of the fact that the mussels are healthy and well fed, there is a great scarcity of them, and they are dwindling fast, although there is plenty of spat, for the woodwork of the piers, and almost any object left in the water for some time, are covered with young mussels. There is a twofold reason for this scarcity of mussels in such a favourable place, one of which is unfortunately unavoidable—viz., the dredging. Every year the bed of the river is artificially deepened and the dredgers take away more and more land, thus actually removing the homes of the mussels. The other reason is that the mussels are not protected in any way, and the fishermen come and take any they can find, searching most carefully. This is the case all over the woodwork of the piers, and

wherever the mussels settle, they are all stripped off directly the animals are large enough for bait. Besides this there was a constant trampling down and crushing of the spat on the bed. Professor Meek, in 1898, regarded the experiment (*i.e.*, the laying down of the mussel bed) as useless, owing to the improvidence of the fishermen.* Professor Gregg Wilson, who visited the beds in 1893, mentions Blyth as admirably suited for the growth of mussels, and thought what it most needed was supervision.† I note that in 1901 the local fishermen obtained good supplies of mussels from the piers at Blyth Harbour. Along the river bank, below the timbers of the piers, particularly on the left bank, there are many spots which would be most convenient for mussel planting. These are well sheltered slopes, the ground is mud and stones, and the tide covers most of it for several hours each day. If this ground could be protected, there seems no reason why mussels should not be planted, but under the present conditions it would be merely wasted labour.

AMBLE (SEE MAP II.).—The mussels of Amble, or Warkworth Harbour, are chiefly on the beach, to the right of the mouth of the River Coquet, where fresh water as well as the sea reaches them. They also grow on the actual river banks, where experiments in mussel planting are being carried on. The most important of these experimental scaups is on the left bank of the river, near the sea, between the stones below and on the south side of the North Pier. This bank forms a steep slope down to the beach at low water. Here mussels from the Tees have been planted by the Northumberland Fisheries Committee, and the fishermen have undertaken not to disturb them. They are growing well, the shells increasing in size and being well filled.

The rocks at Amble are Coal Measure sandstones. The mussels on the right side of the river cover the flat rocks lying between the tide marks, and also occur on the sand between the rocks and the loose stones, but there are none beyond low water mark. The rocks are much covered by *Fucus vesiculosus*, and the mussels lie densely packed together. Owing to this they are of small size ($1\frac{3}{4}$ to 2 inches in length). There is certainly no dearth of mussels here, but a systematic thinning would surely improve them, for they are

* Report Northumberland Fisheries Committee, 1898, p. 33.

† "Report on the Crab, Lobster, and Mussel Fisheries in Northumberland."—Northumberland Sea Fisheries Committee, 1893.

far too closely packed to grow to any size. The fishermen gather these mussels constantly for bait, and use two to each hook, but they still continue to grow in this particular spot as thickly as ever. Some of the smaller of these were transplanted to the experimental ground on the other side of the river, but they did not increase in size, and most of them died.

All the animals seen were healthy, their stomachs containing much mud full of food-stuff, chiefly Diatoms. Specimens examined at the end of September were all spent, and continued to be thin until about January, when they were perceptibly filling out, and increased until the end of April and May, when many were quite ripe. This is evidently the beginning of the spatting season. The experimental mussels were not so far forward, probably owing to the transplanting.

Few other mollusks live with the mussels on the right bank; *Littorina littorea*, *L. rudis*, and *L. obtusata* are fairly abundant, and on the left bank *Cardium edule* and *Macoma balthica* are common. *Mya arenaria* also occurs higher up.

More transplanting of suitable material to the left bank of the river, and protection during the spatting season seem to be the essentials in order to get good mussel bait from the Coquet. That spat is abundant is shown by the crowds of mussels clinging to anything suspended in the water and wherever they can get shelter. Also it is shown by the masses of smaller mussels clinging together on the rocks. A thorough thinning of these would be useful in order to enable the mussels to attain a larger size, and this should not be difficult to accomplish.

ALNMOUTH (SEE MAP III.).—Along the banks of the River Aln, below the bridge, there is much wet mud, which lies on sandstones and shales of the Carboniferous Limestone series, but the only place where mussels occur is the old course of the river. These mussels have had a curious history. In 1806, during a tremendous storm, the course of the river was changed in one night, and the hill on which the old church stood was completely cut off from the village. The following extract from a paper by Mr. George Tate is interesting.* “Formerly the Aln found an outlet through a breach southward of the Church Hill, which was then united to the Cheese Hill by a low ridge. Time after time the

* “An Account of Lesbury Parish.”—Proc. Berwickshire Naturalists’ Club, 1877, p. 247.

currents and tides acted on this ridge, and in 1806 broke through it, so that at high tides the Church Hill was an island. . . . A heavy sea in 1806 deepened the breach, and since then the river has always run through it, and the channel has been blocked up by sand." There is now very little water in this old channel, which is merely a broad expanse of sticky and slimy mud. The mussels cover the mud thickly in places, but are all very small and thin, too small and thin to be of any value as bait. It is evidently too dry for them, as they do not now get covered for any length of time by the tide, and apparently there is not sufficient food, as the stomachs are almost invariably empty. Some of the fishermen remember when the mussels were good enough to be used for bait, so this must once have been a flourishing bed. The animals are unhealthy and the shells are very thin, many dead shells occurring with the living specimens. The largest shells measure $1\frac{1}{8}$ inches in length, but most of them are much smaller. Although all the specimens examined in October and November were quite thin all over, in the Spring the reproductive lobes were spreading into the mantle to a small extent, so that they probably still shed some spat.

A small form of *Littorina rudis* is found with the mussels, and fairly large *Littorina littorea* and *Cardium edule* also occur; *Macoma balthica* is common.

It is clear that these mussels are deteriorating rapidly and are dying out, and there seems to be no fit place near the river mouth or on its banks where mussels might successfully be planted. The river banks near the sea being composed almost entirely of soft sand, the locality is most ill-adapted for mussel growing. Attempts were made to form both oyster and mussel beds, but they were unsuccessful, for the mud brought down by the river during floods smothered and destroyed both.

The question arises whether these mussels could be transplanted to some more favourable locality before they all die. Arrangements are being made to try this and to deposit a few of these mussels on the experimental scaup at Amble. It remains to be seen whether the mussels are too far gone to be capable of recovery.

BUDLE BAY (SEE MAP IV.).—Budle Bay is an extensive sandy flat where the River Waren flows into the sea. At low tide the sands extend a long way, nearly to Holy Island, which is visible in the distance. It is on this flat that one of the best mussel beds occurs. The bed is now rented from Mr. Brown, of Callaly, by Mr.

Mitchell, of Bamburgh, and is being carefully cultivated by him in continuation of the work begun under the direction of Mr. William King. In 1890, the supply from this spot being very small, an attempt was made to restock the beds. The native mussels were collected together, and the ground near them cleared to encourage the lodgment of spat.* Since then much care has been taken of the beds, with a fair amount of success. The greatest and most serious difficulty to contend with is the storms, which carry away the spat. Stone walls have been erected for the shelter of the mussels, which mitigate to some extent the force of the waves. Wattling has also been tried, but without much success. In spite of the storms, however, the mussels are good and increasing.

The bay to the north is on the Basalt of the Great Whin Sill, and on the south bank of the Waren there is limestone of the Carboniferous Limestone series. It is chiefly on this south side that the mussels grow. A large mass of small mussels was thriving well in 1905, which had lodged on ground to the south-east, at some distance from the other mussels. The spatting in 1904 and 1905 was particularly satisfactory. The spat lodges generally on the ground where there is fine gravel mixed with clay and where the tide covers them only for two to four hours a day or less, consequently when the mussels grow bigger they have not enough food, and die for want of it. Those that lodge at the four hours level grow bigger, but still have not enough food; transplanting is therefore necessary. The mussels are from a year and a half to two years old when they are lifted and planted in the stream-channels, where they are covered for six to seven hours each tide or even not uncovered at all, and these last are perhaps the best. Fig. I. shows part of the bed at Budle, where the mussels are about four hours out of water at each tide; in the background the mussels are always under water. The mussels reach bait size quickly, and are generally allowed to fatten for a year, so that at four years they are ready to be sold for bait or food, but are often left until they are five or six years old. The uncovered mussels are to be seen in groups of five or six, with a little seaweed, *Fucus serratus*, and partly buried in the sand. They are large, 3—3½ inches long or more, and these are from four to six years old. Those attaching themselves to stones are smaller, and many of these grow on the specially built low stone walls. They

* See Professor A. Meek, "On Mussel Culture on the Coast of Northumberland."—Northumberland Fisheries Report for 1898, p. 33; and Mr. William King, "Mussels and Mussel Culture," 1891.



FIG. I.



FIG. II.

are more crowded and exposed, which accounts for the difference in size. Fig. II. shows the screen on which the bait mussels are placed, and those that fall through between the bars are taken back to the beds to grow bigger. The space between the bars is about $\frac{5}{8}$ inches. Mussels about this thickness and as long as two inches are considered a fair bait size. On the north side of the Warren a large area is covered with sea-grass, *Zostera marina*; but although spat frequently settles here, it always dies off and never grows to any size. The sea-grass does not seem to be such an effective shelter for the mussels as *Fucus serratus*. The latter is sometimes swept away by the storms, and when once this is withdrawn the mussels are soon carried off and lost. *Fucus vesiculosus* also affords valuable shelter.

Close to the river, just above the mussel bed, is a small oyster bed, enclosed by walls on which grow many good-sized mussels. The Budle mussels altogether are fine and healthy, those from the sand and stream-channels are as a rule smooth, and little overgrown with other animals or plants, although those in the streams are much bored by the Annelid, *Polydora ciliata* (see end of paper). Those from the stones are frequently covered with the common barnacle, *Balanus balanoides* (L.). The stomachs are full of food, chiefly vegetable, but microscopic crustacea are present in fair numbers. There are almost equal proportions of male and female mussels. According to Mr. King* the mussels spawn in July, August, and September, but are much influenced by temperature, a cold season delaying the process considerably. Mr. Mitchell finds that there are two breeding seasons, one in Spring and one about August. The mussels last year (1906) were certainly ripe at the end of April, but the spatting continues in the summer months and is quite over by the beginning of October, by which date all the mussels are spent. The largest deposits of spat occur at the end of the summer.

Some of the commonest mollusks living on the beds are *Cardium edule*, *Mya arenaria*, *Lutraria elliptica*, *Macoma balthica*, *Littorina littorea*, *L. rudis*, *L. obtusata*, *Trochus cinereus*, *Purpura lapillus*, and *Patella vulgata*.

The facts stated above show that Budle is being well looked after, and little can be suggested for its improvement as a mussel farm.

* Op. cit., p. 4.

HOLY ISLAND (SEE MAP V.).—The Holy Island mussel beds, which occur on Fenham Flats, between the island and the mainland, occupy the largest area of any of the Northumberland beds. The flats consist of a large expanse of muddy sand with stretches of gravel, overlying sandstones, shales, and limestones of the Carboniferous Limestone series; the basaltic dyke (the Holy Island Dyke) which runs through these strata being too narrow to be taken into account for the present purpose. Most of the flats are uncovered at low tide, but certain parts are always covered. Small burns from the mainland run across the flats, and thus a mixture of fresh and salt water is effected. The mussels occur chiefly on the more gravelly ground, and are separated from Holy Island by comparatively deep water even at the lowest tides. The best specimens are to be found on the Oyster Scaup, and stretch out for some way south over Madges' Batts and south-west to within about a third of a mile from the mainland. There are no good mussels east of the scaup except on the slakes, which are from half a mile to a mile from the mainland opposite Holy Island. One of the deeper channels of water cuts the scaup off from the sandy and muddy flat which separates Holy Island from the mainland, and can be crossed on foot at half tide. In this sandy part very small mussels are sometimes seen covering the ground, having been swept there by the tide, but these soon die, probably being uncovered for too long a time, and having no proper shelter. The slakes also yield mussels, but not of such good quality as those from the scaup. The ground here is soft and dangerous and covered with sea-grass, the mussels occurring at intervals in large patches by the Foulwork Burn (on both sides) and by Mill Burn. People walking along this part sink into the mud from four to fifteen inches. The fishermen come here for bait when the scaup is not uncovered, and sometimes transplant the mussels to the scaup to fatten and grow to a larger size. Hen Pool—a small pool near the Beacons, surrounded by sand and always having sea-water in it—contains very good mussels, which grow well, although no fresh water, except rain, ever reaches it, and the mussels are never uncovered. The sea enters this pool about two hours before high water. Another bed is located between the island and the mainland to the north, at the end of the Snook, but here the blowing sand often destroys the mussels, choking them up and killing them. A large stretch of these shells in this place looks at first sight like a flourishing mussel bed, but when closely examined all the shells

are seen to be dead. The mussels on the scaup are only uncovered during spring tides. At neap tides almost the whole is under water, the only accessible mussels being those on the slakes. The scaup mussels are the biggest, and grow well, although there is much gravelly space vacant here which might well be covered with them. They have lately decreased in this area, probably owing to the ravages of the small white whelk *Purpura lapillus*, which abounds there, covering the stones with its vase-shaped spawn (April and May). The fishermen bring the smaller mussels from Madge's Batts and thereabouts, and plant them on the scaup to grow to a suitable size, and when they are from about $1\frac{3}{4}$ to $2\frac{1}{2}$ inches in length they take them for bait. There are not many of these larger mussels, as the fishermen only transplant as many as they want for their own use. Many more small mussels might be transplanted. The old mussels which are the natives of the scaup are larger, and have thick and coarse shells. It is quite easy to distinguish them from the others, but there are few of these left now. The small Pea Crab, *Pinnotheres pisum*, L., is a constant inhabitant of these natives, but beyond perhaps making them thinner does not appear to deteriorate them.

The mussels on the scaup and most of those on the slakes are owned by Lord Tankerville; the remainder, on the northern part of the slakes, belong to Mr. Leyland, of Haggerston. The fishermen of Holy Island pay one shilling a year each to Lord Tankerville for the right to gather the mussels.

Crabbing is the chief industry of Holy Island. The crab-pots are baited with fish, but as the lines on which the fish are caught are chiefly baited with mussel, a great many of these shells are wanted. The demand, however, does not exceed the supply, as there are many more mussels on Fenham Flats than are wanted by the local fishermen. They are small only because they are not properly cultivated.

At spring tides the whole scaup is uncovered for two hours each tide, and it is only for a short time that the ground is available for collecting shell-fish. A few oysters occur here, but they are not natives; the true old natives, which were of a particularly large size, are extinct.

The Holy Island mussels are healthy and well fed, their stomachs being full of microscopic vegetable food. By the beginning of October they had finished spawning. During the Winter months they were filling out well, and were nearly ripe in May. The breeding season seems to be much the same as Budle.

Some of the common mollusks on the beds are *Cardium edule*, *Solen siliqua*, *v. arcuata*, *Tapes pullastra*, *T. virginea*, *Mya arenaria*, *Dosinia exoleta*, *Lutraria elliptica*, *Littorina littorea*, *L. rudis*, *L. obtusata*, *Purpura lapillus*, *Buccinum undatum*, and *Patella vulgata* on the scaup, and in the other part of the flats, near the slakes particularly, *Macoma balthica*, *Scrobicularia tenuis*, and *Faludestrina stagnalis*.

There is certainly much room for transplanting the mussels on the scaup, good ground is plentiful, and small mussels which might be thus used are abundant. The slakes are apparently not so well adapted for the cultivation of mussels, the extremely soft ground being a drawback, also the tide being for too long a time off the beds. Prolonged frosts materially affect the beds, especially those which are uncovered for many hours a day.

BERWICK-ON-TWEED (SEE MAP VI.).—Mussels occur in the Tweed in the bed of the river, on the side opposite the Spittal, from below the bridge to the end of the pier, extending from low water mark of ordinary tides to about the middle of the river. A few are found above the bridge (but these are generally choked by mud) and they do not extend out to sea beyond the pier. None are found on the south side. The mussels are thus covered by water except at the lowest spring tides, and even then there are many still under water, which have to be dredged. The bottom on which the mussels lie is gravelly mud stretching over the lowest beds of the Carboniferous Limestone series, consisting of rapidly alternating sandstones, shales, and thin limestones. The mussels are grouped in small clusters, with seaweed (*Fucus*) and small stones attached to them, and are a good size (2 to 2½ inches long). Those nearer low water mark, which are less covered by the tide, are of the variety *galloprovincialis*, and lie buried in the ground. These are small (average size 1¾ to 2 inches long), but quite healthy. The stomachs were full of food, chiefly vegetable. At the end of September they were mostly thin, but the mantles were beginning to fill out, which seemed to indicate that the breeding season is over by the end of August.

The only mollusks seen with the mussels were *Littorina littorea* and *L. rudis*.

The fishermen take the smaller mussels and transplant them up the river, but they still do not have enough for bait, and buy much from Morecambe, keeping it in water a little north of Berwick, by

the bathing ponds. A suggestion has been made to plant the small mussels on the north bank of the river, where gravel and stones abound, and where there is a large stretch of land left uncovered by the tide every day, but they would hardly get enough food there for them to grow to any size. A better plan would seem to be for the fishermen to plant more mussels up the river, as they have already done in a small way with success. There appears to be no reason why, with more cultivation, this bed should not yield enough bait for the fishermen both of Berwick and the Spittal.

ENEMIES OF THE MUSSELS.

The mussels on this coast have not many enemies, but by far the most important of these is the starfish, *Asterias rubens*, which constantly preys upon them. A formerly flourishing bed near the Tyne has lately been exterminated by this starfish (see ante p. 4), and it is a bad enemy nearly everywhere. *Purpura lapillus* devours the mussels on the scaup, Holy Island, and here in parts the devastation caused by this small and very destructive mollusk is great. It does not, however, appear to be a scourge elsewhere. The only possible way of dealing with such foes would be to destroy all starfish whenever found, and to collect the *Purpura lapillus* systematically, and also its spawn, and destroy both. It would probably take a very long time to make any perceptible difference in the number of *Purpura lapillus*, as they are so abundant, but if the vase-shaped spawn, so easily seen, were destroyed whenever met with, the numbers are bound to diminish in time.

Many birds eat the mussels, notably the Oyster Catcher and species of wild duck,* especially in the Winter. The Oyster Catchers on this coast often have their stomachs full of the remains of mussels, with cockles, limpets, and chitons, but the prevailing opinion among the fishermen is that they eat more limpets than mussels, and perhaps these birds are not common enough to make any material difference in the number of mussels.

In the Budle and Holy Island mussels, especially the former, the shells are much attacked by the boring annelid *Polydora ciliata*, which also frequently invades the periwinkles of the Holy Island scaup. Inside the mussels several larval Trematodes were found.

* For a list of birds that eat mussels see "Some Trematodes in *Mytilus*," by the writer. Proc. Univ. Durham Phil. Soc., 1906, p. 231.

The presence of *Polydora ciliata* at Budle is a real evil, but one which I fear it is impossible to cure. It is a worm well known for burrowing into shells and limestone, and its presence is probably due to the proximity of the oysters. *Polydora* burrows much into these, and is much larger in them than when inhabiting the mussel shells. One measured over $2\frac{1}{2}$ inches in length, and those in the mussel are seldom longer than $1\frac{1}{4}$ inches. The interesting point about these burrowing worms is that they cause the mussel to grow pearly excrescences, which cover the internal surface of the shell, sometimes to an enormous extent, especially in the large mussels from the bed of the stream, and thus often materially interfere with their muscular development. In some cases the byssal muscle and the posterior retractor of the foot were hanging by a few strands, and great pearly lumps were projecting into the



FIG. III.

muscle, in nearly every case caused by *Polydora*. Frequently the posterior adductor muscle was almost destroyed in this way (see Fig. III.). Although the remainder of the animal generally appeared healthy, this must eventually be a cause of death to the mussels, relying as they do so much on these tissues in closing their shells when danger threatens and for use of the byssus and foot. In some cases, where these pearly masses project and press upon the mantle, the reproductive lobes, present elsewhere, are quite absent in patches, leaving perfectly clear spaces. Sections of the mantle show the entire absence of reproductive lobes in these clear patches (see Fig. IV., section of mantle of mussel showing reproductive lobes on the right and their complete absence on the left where the pearly excrescences have pressed). Here again one sees the deteriorating effect of *Polydora* on the mussel. The worm enters from the outside—the small holes the size of a pinprick can often be seen on the mussel shell,—it then makes a U shaped burrow, which sometimes, but not always, reaches the nacreous layer of the shell, and in two cases it had come right through to the inside, the tubes of the worm hanging out into the space between the shell and the mantle. In one specimen four worms had pierced through, but this is unusual. *Polydora* is nearly always the cause of the pearly excrescences within the mussel shell, but in one case a small mussel was found to be the cause of a large excrescence. The mussels lower down in the

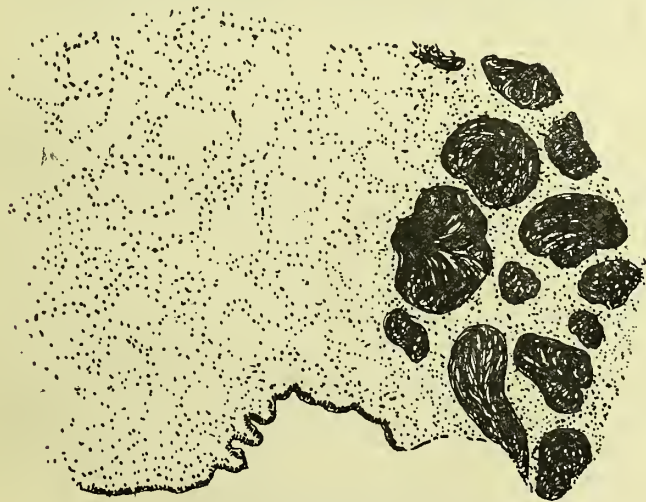


FIG. IV.

Budle bed to the south-east are not attacked by *Polydora* nearly so frequently, only one or two specimens out of many examined contained their excavations, and these only singly, whereas those above-mentioned were often quite riddled with them. This fact seems to point to the oysters as the cause, for the nearer the mussels are to the oysters the more are their shells bored by *Polydora*. Apart from being a cause of death in a slight degree to the mussels, the presence of these excrescences is probably a disadvantage in those destined for selling for food in the market, as they have a most unsightly appearance when opened.

The larval Trematodes inhabiting the mussel are three in number, viz.:* in the mantle the cercaria of the "Pearl Trematode," in the foot the encysted cercaria of *Echinostomum secundum* (Nicoll), and in the liver an encysted form not yet determined. Although I have classed them among the enemies of the mussels they appear to do very little harm to their host, even when present in large numbers.

The "Pearl Trematode," which Dr. Lyster Jameson proved to be the cause of the mussel pearls,† is the cercaria of an adult form living in the Eider Duck. Odhner‡ is of the opinion that this is *Gymnophallus bursicola* (Odh.), and not *G. somateriae* (i.e., *Leucithodendrium somateriae*), as Jameson suggests. The tail-less cercaria occurs free on the mantle of the mussel before it is covered over with nacre. The previous host at Budle is *Cardium edule*, in which it occurs abundantly underneath the hinge in masses of sporocysts, but although found so frequently in this stage it is not nearly so often seen in the mussels. Pearls, however, occur in numbers at Budle, so that if each pearl means a worm, the cercaria must succeed fairly often in reaching its second host. An interesting mussel was found (see Fig. V.), having a ridge on the mantle composed entirely of separate pearls, probably a hundred or more. The length of the mussel was $3\frac{1}{4}$ inches, and the ridge was $1\frac{1}{2}$ inches long. This may have been due to an inrush of Trematodes, apparently a most unusual occurrence.

None of these worms were found in the mussels from the other Northumbrian beds, although there are a good many pearls in those from the Holy Island scaup. At Berwick, Amble, and Blyth there are very few pearls, and none at all were found in the mussels from Alnmouth.

* See "Some Trematodes in *Mytilus*," op. cit.

† Proc. Zool. Soc., London, 1902, p. 140.

‡ "Die Trematoden des Arktischen Gebietes, 1905, p. 25.

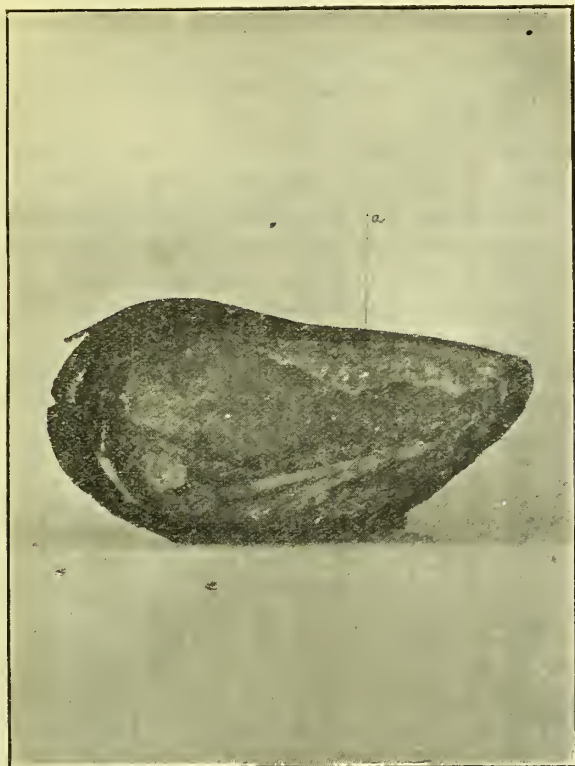


FIG. V.

The Trematode from the foot of the mussel is the encysted cercaria of *Echinostomum secundum* Nicoll, which in the adult state inhabits the Oyster Catcher and certain gulls.* It is very common at Budle in the foot of both the mussel and cockle, but especially in the former, where almost every specimen is infected. It is fairly common at Holy Island, and was found in one specimen from the Tweed. In those examined from Blyth, Amble, and Alnmouth it was not present. I believe I have found the previous stage in the common periwinkle *Littorina littorea*, where in about two per cent. of these mollusks from Budle I found the liver full of orange rediæ, containing tailed cercariæ which agree closely with the encysted forms.† I had hoped to make experiments as to the

* Nicoll. Ann. and Mag. Nat. Hist., 1906, p. 148, and June, 1907, p. 313.

† Northumberland Fisheries Report for 1905, p. 100.

infection of mussels by these cercariæ from the periwinkle, and for this purpose procured a lot of periwinkles from Stranraer, where the parasite abounded in August and September; I was, however, much disappointed to find no parasite of this kind in them (January). Specimens examined from Budle in January had young rediæ in two of them, and one had a small number of full-grown cercariæ in it. It seems clear that the time for the migration of this parasite into another host must be the autumn, and the young larva would go into the periwinkle most likely in the early Winter and Spring. From these observations it appears that the right time to make infection experiments would be the Summer months, and I hope to carry on some of these experiments at the first opportunity. These Trematodes were found in the periwinkles from the Holy Island scaup, but not in those from any of the other mussel beds.

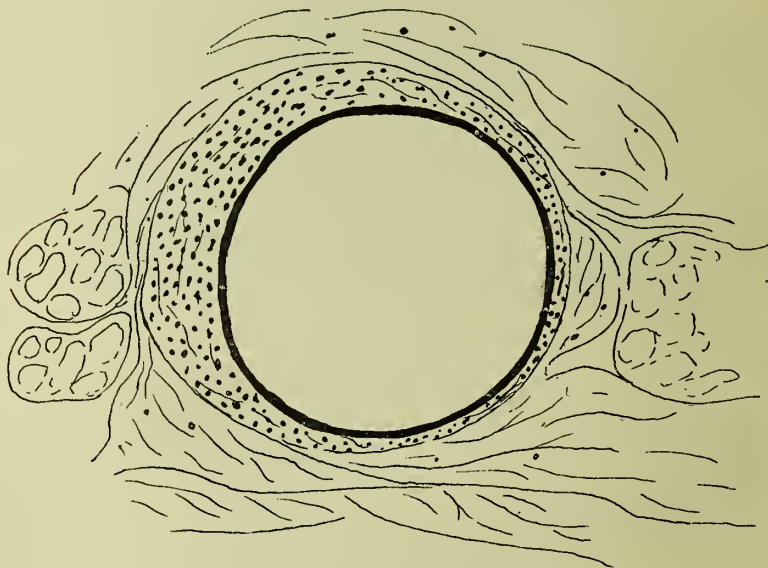


FIG. VI.

The mussel is not materially affected by the encysted worm. The foot is made up of a central glandular mass surrounded by muscular tissue, and the worm encysts in both parts, but more frequently in the muscular portion. Sections through the foot show a multiplication of nuclei in the tissue immediately surrounding the cysts (see Fig. VI—section of foot of mussel stained

with gentian violet and orange G, the nuclei and the cyst staining deeply with gentian violet). It is interesting to compare this with the cysts of epithelium surrounding the "Pearl Trematode" described by Dr. Jameson,* showing how very differently the presence of Trematodes affects different tissues.

The encysted worm from the liver of the mussel was briefly described by me last year,† but very little structure was made out beyond two suckers and a conspicuous glandular excretory system. It is common at Budle and Holy Island, and was found sparingly at Amble.

Besides the Trematodes from the mussel, many more were found in the other Mollusca associated with them in the beds, and these I examined whilst searching for the early stages in the life-histories of the above-mentioned forms. The results of these investigations have nearly all been already published.‡

Many encysted forms were found in the crustacea near the beds which I hope to investigate more closely hereafter.

EXPLANATION OF FIGURES.

FIG. I.—Part of Budle Bay at low water.

FIG. II.—Mussels being put through screen, Budle.

FIG. III.—Mussel shell from Budle showing pearly excrescences due to *Polydora ciliata*.

FIG. IV.—Section of Mantle of Mussel showing effect of *Polydora ciliata*.

FIG. V.—Mussel with ridge of pearls—gills (a); foot and left mantle cut away.

FIG. VI.—Section of Foot of Mussel showing cyst of *Echinostomum secundum*.

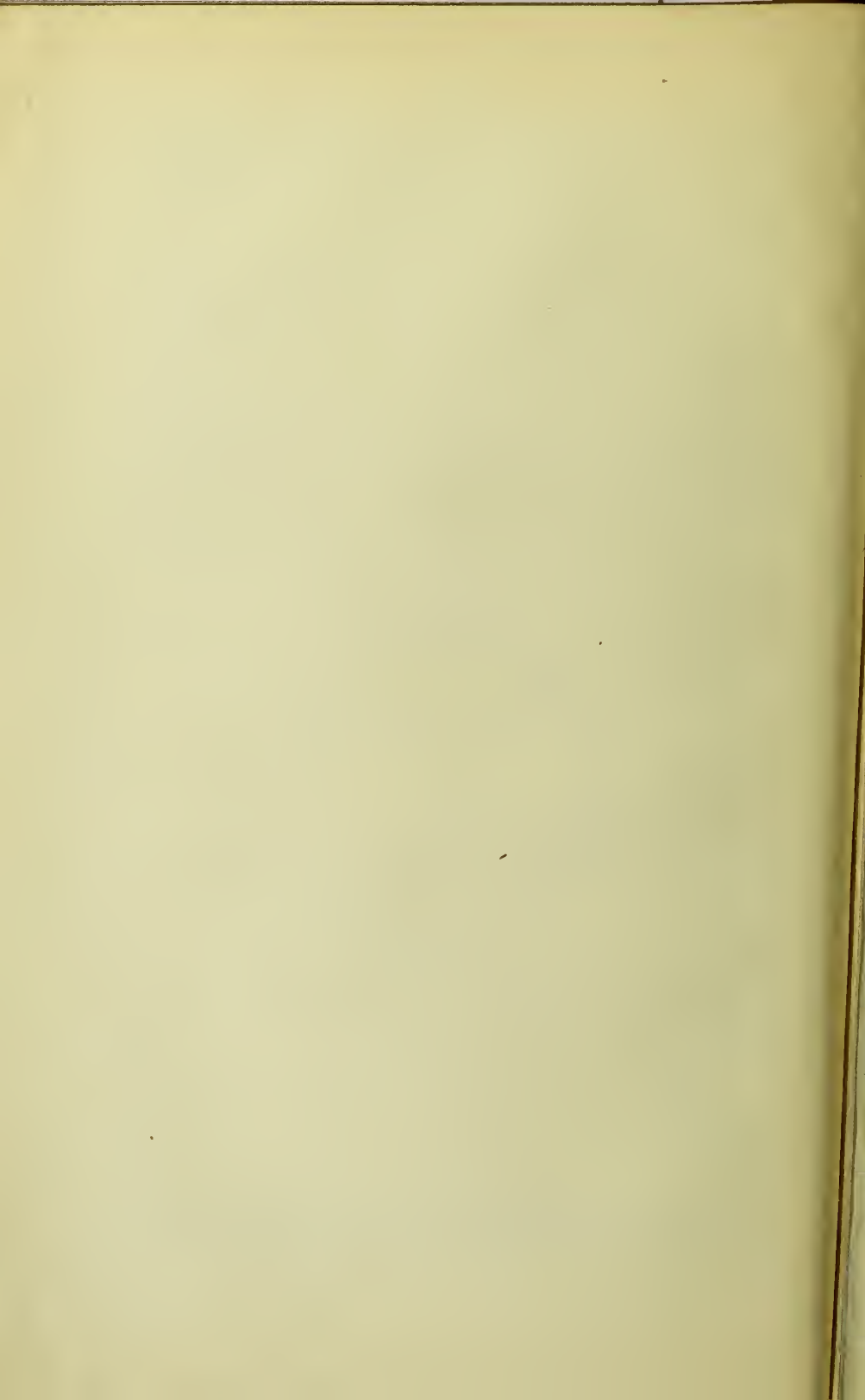
MAPS.—These are all on a scale of $1\frac{1}{2}$ in. = 1 mile.

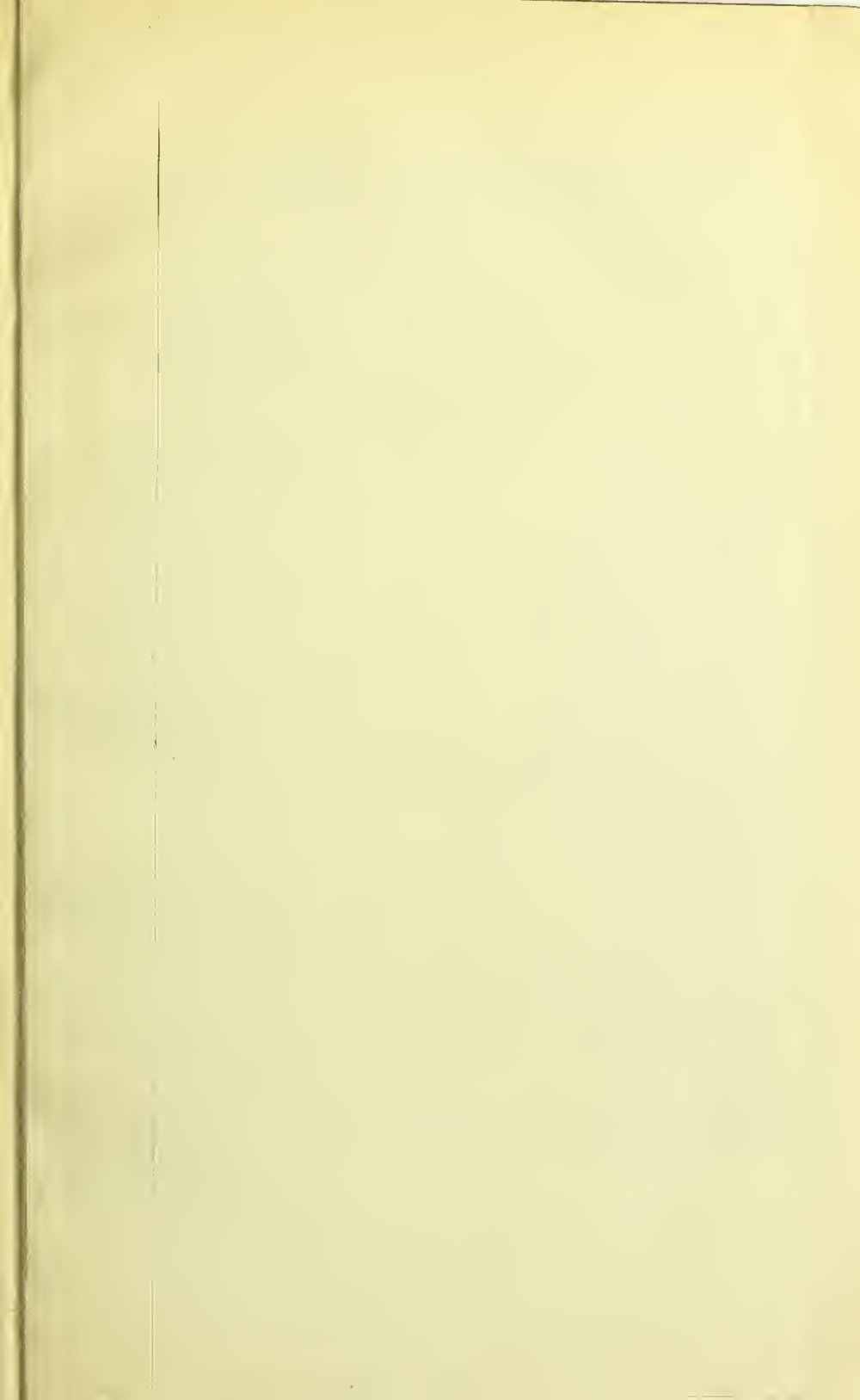
The areas occupied by Mussels are indicated by diagonal shading. Uniform shading denotes land, and sandy areas are shown by means of dots.

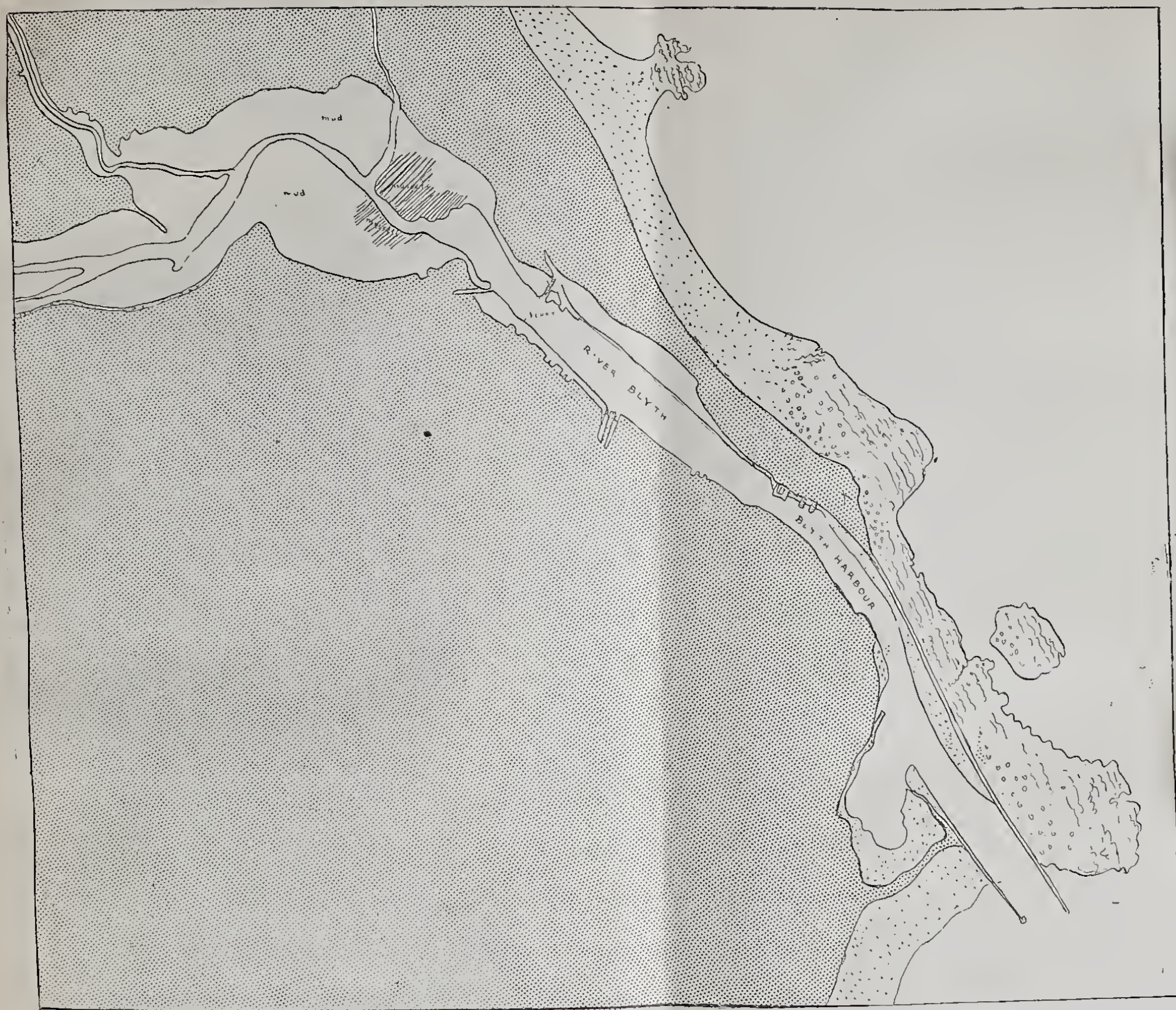
* Op. cit.

† Northumberland Fisheries Report for 1905, p. 102.

‡ Northumberland Fisheries Report for 1905, p. 100. Ann. and Mag. Nat. Hist., Jan., 1907, p. 102. Trans. Univ. of Durham Phil. Soc., 1906, p. 231. Trans. Nat. Hist. Soc., Northumberland and Durham, Vol. I., N.S., Part III., 1907, p. 437.

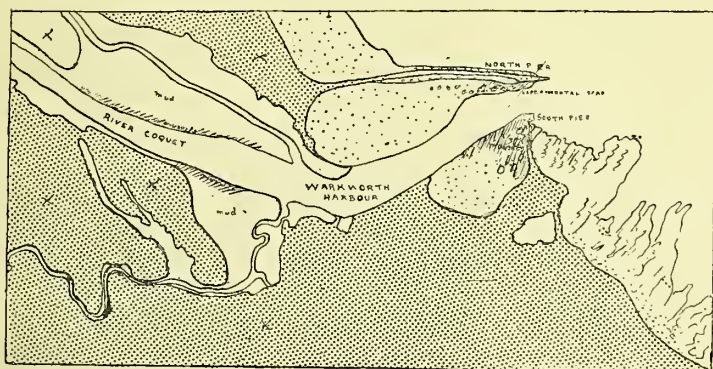




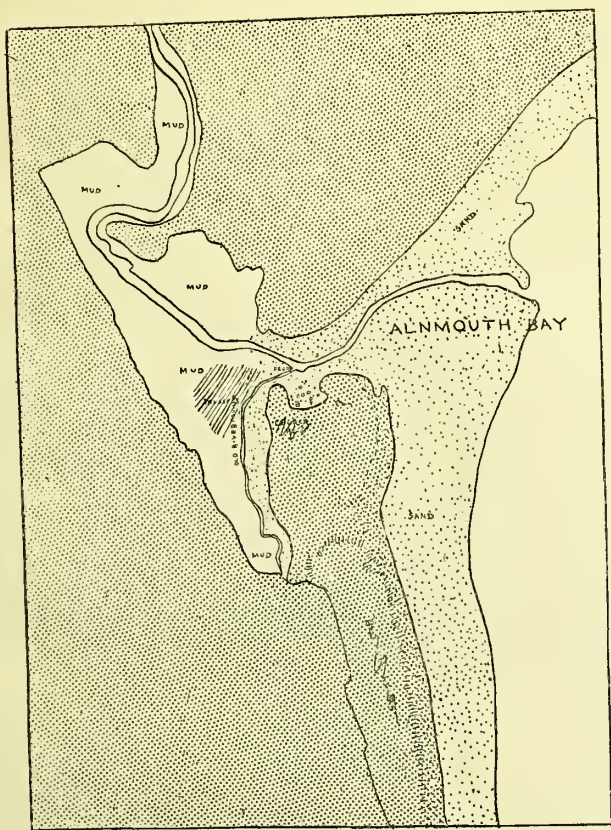


MAP I.—BLYTH.



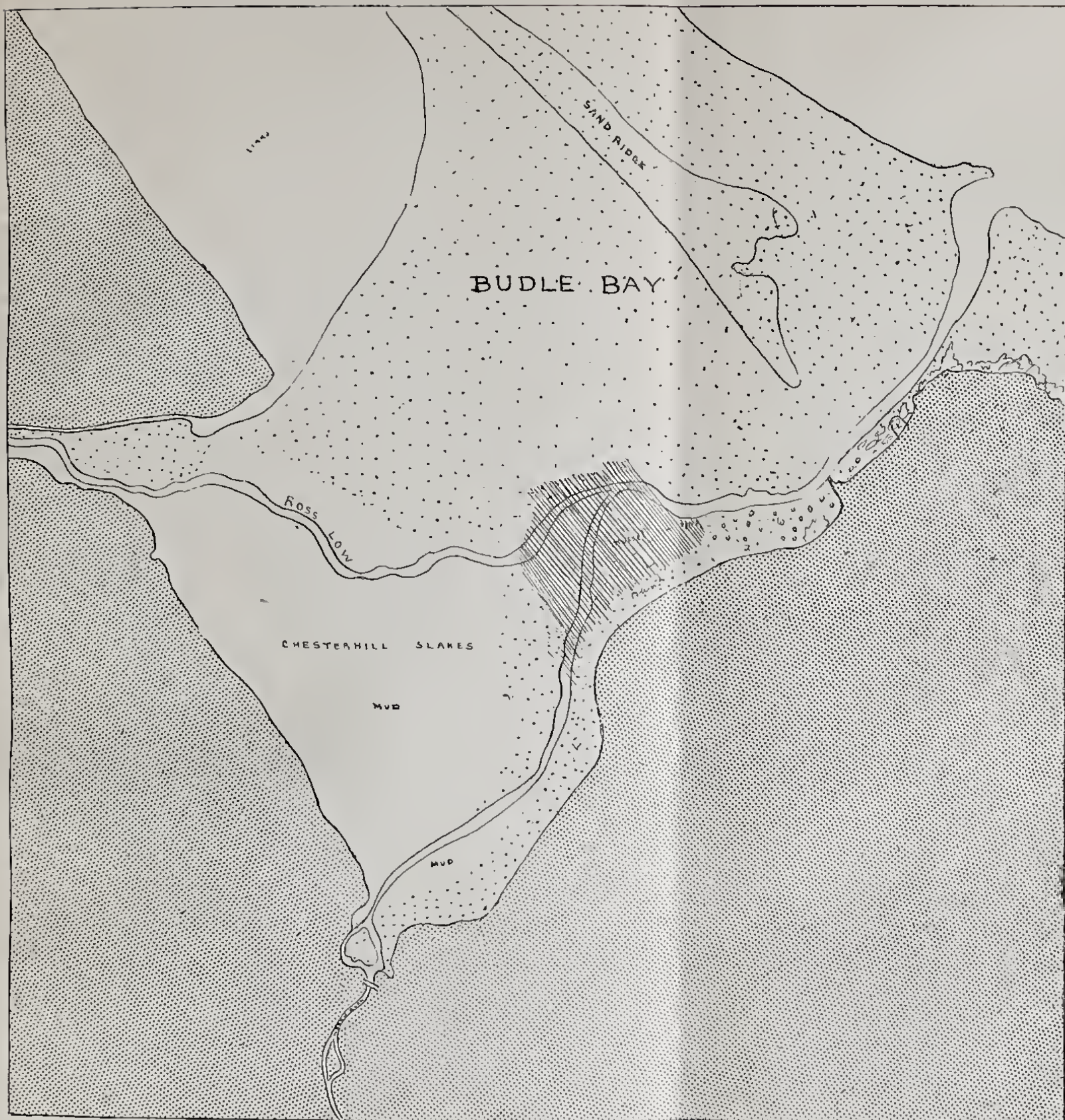


MAP II.—AMBLE.



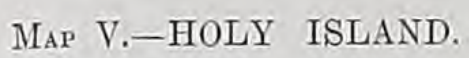
MAP III.—ALNMOUTH.





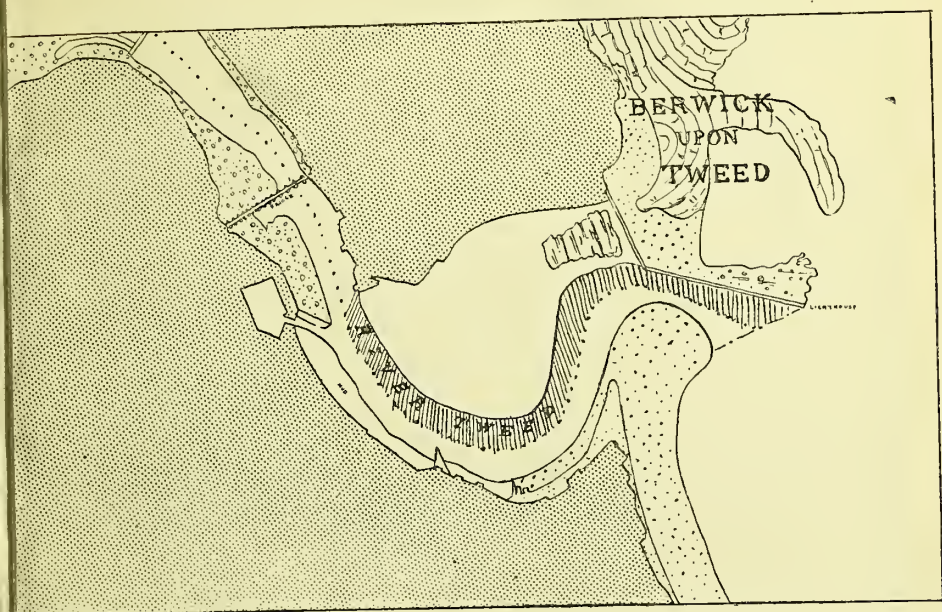
MAP IV.—BUDLE BAY.





MAP V.—HOLY ISLAND.





MAP VI.—BERWICK-ON-TWEED.



